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Rashed et al.

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(54) **MIDDLE-OF-THE-LINE CONSTRUCTS
USING DIFFUSION CONTACT STRUCTURES**

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Related U.S. Application Data

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H01L 23/538 (2006.01)
H01L 29/78 (2006.01)

H01L 27/092 (2006.01)
H01L 27/02 (2006.01)

(52) **U.S. Cl.**
CPC **H01L 23/5386** (2013.01); **H01L 23/5384** (2013.01); **H01L 27/0207** (2013.01); **H01L 27/0924** (2013.01); **H01L 29/7851** (2013.01)

(58) **Field of Classification Search**
CPC H01L 23/5386; H01L 23/5384; H01L 29/7851; H01L 27/0924; H01L 27/0207
USPC 438/622, 669, 599; 257/206, 211, 775, 257/E21.59, E23.011, E21.249
See application file for complete search history.

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Primary Examiner — Kyoung Lee

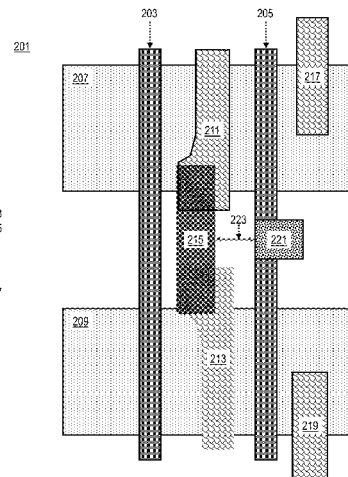
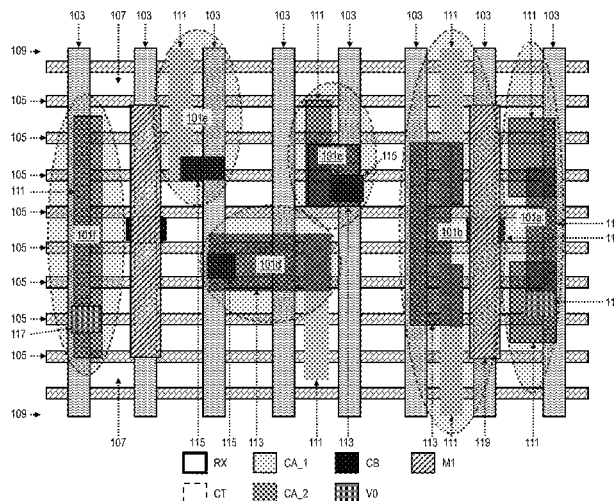
Assistant Examiner — Ratisha Mehta

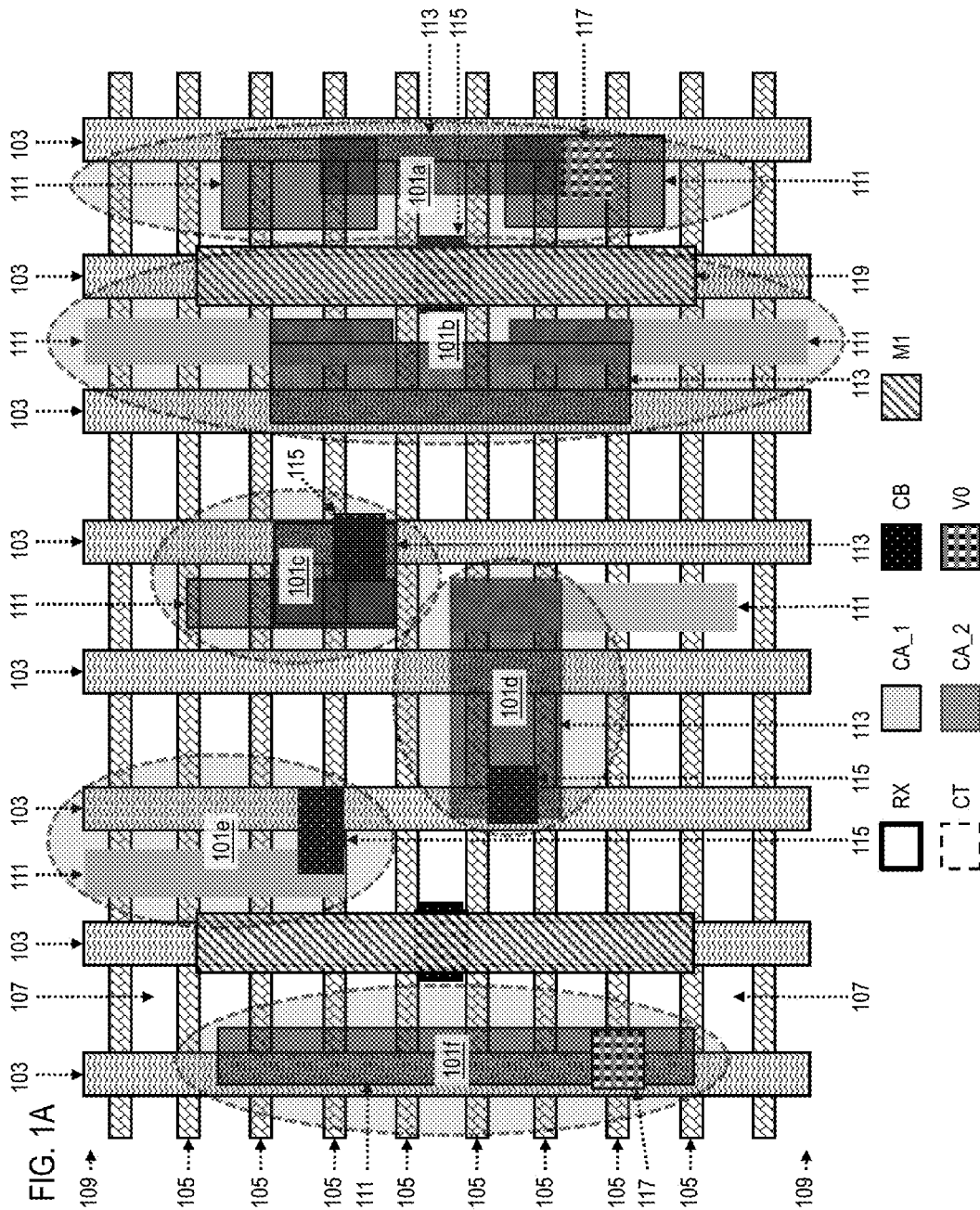
(74) *Attorney, Agent, or Firm* — Ditthavong & Steiner, P.C.

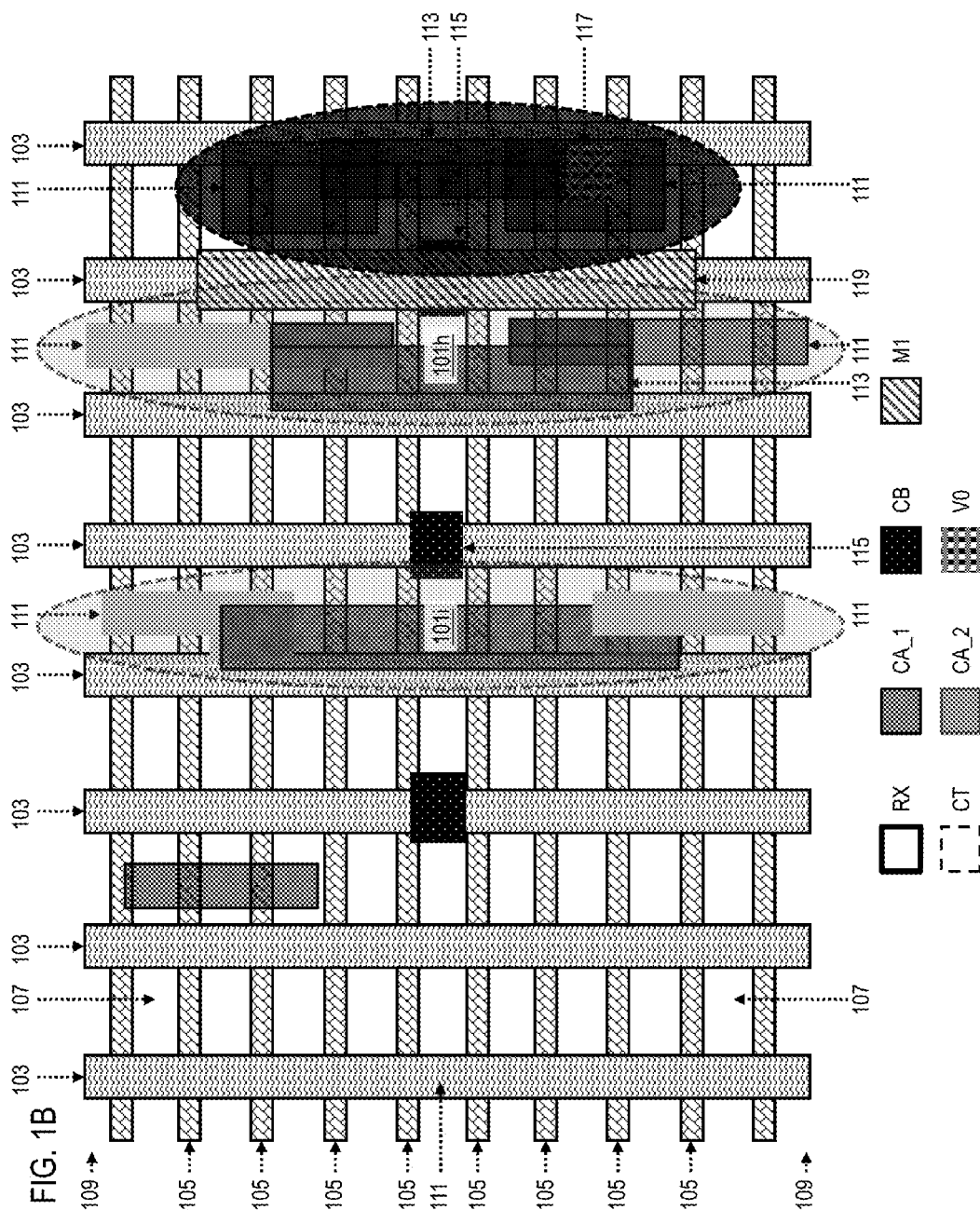
(57) **ABSTRACT**

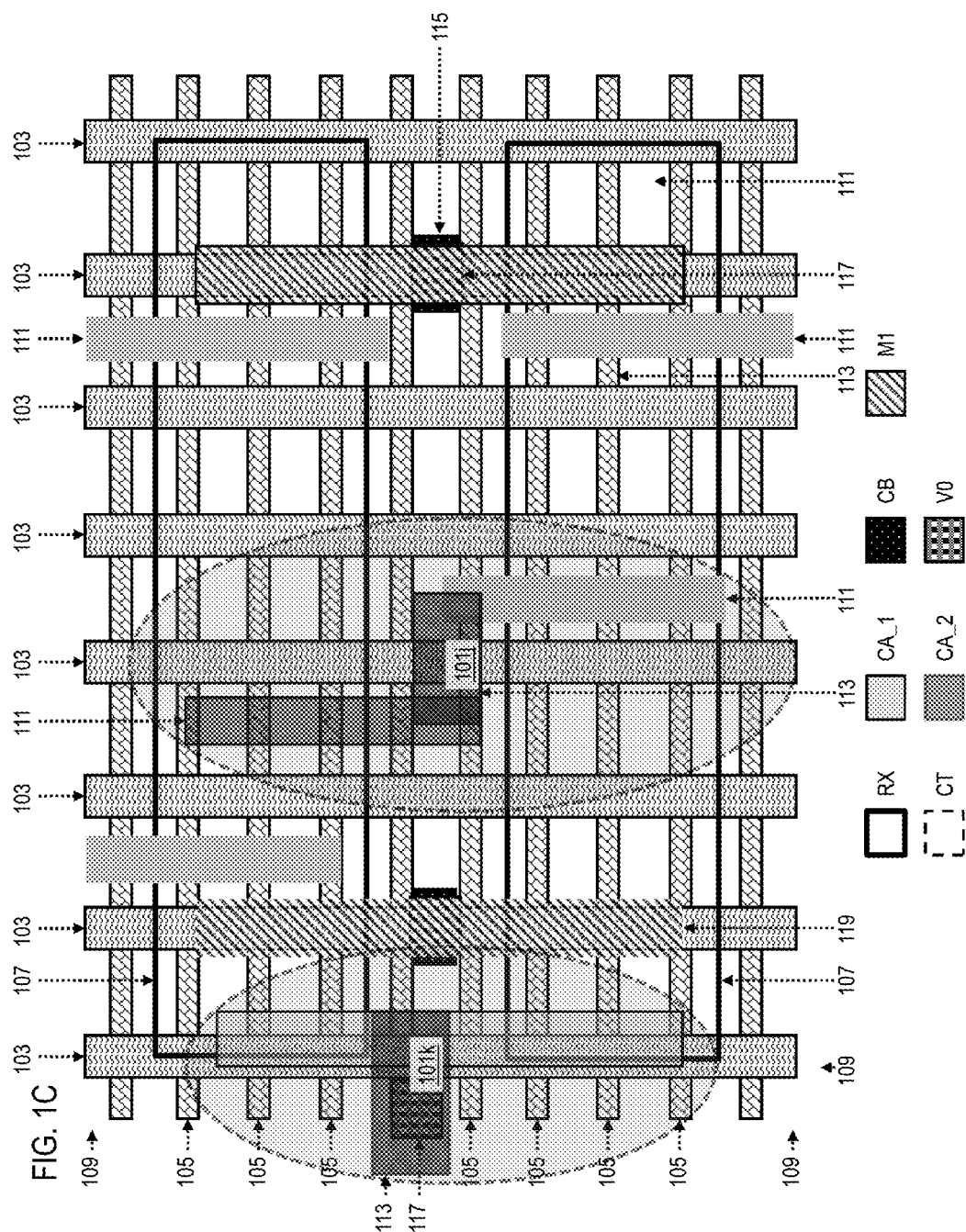
An approach for providing MOL constructs using diffusion contact structures is disclosed. Embodiments include: providing a first diffusion region in a substrate; providing, via a first lithography process, a first diffusion contact structure; providing, via a second lithography process, a second diffusion contact structure; and coupling the first diffusion contact structure to the first diffusion region and the second diffusion contact structure. Embodiments include: providing a second diffusion region in the substrate; providing a diffusion gap region between the first and second diffusion regions; providing the diffusion contact structure over the diffusion gap region; and coupling, via the diffusion contact structure, the first and second diffusion regions.

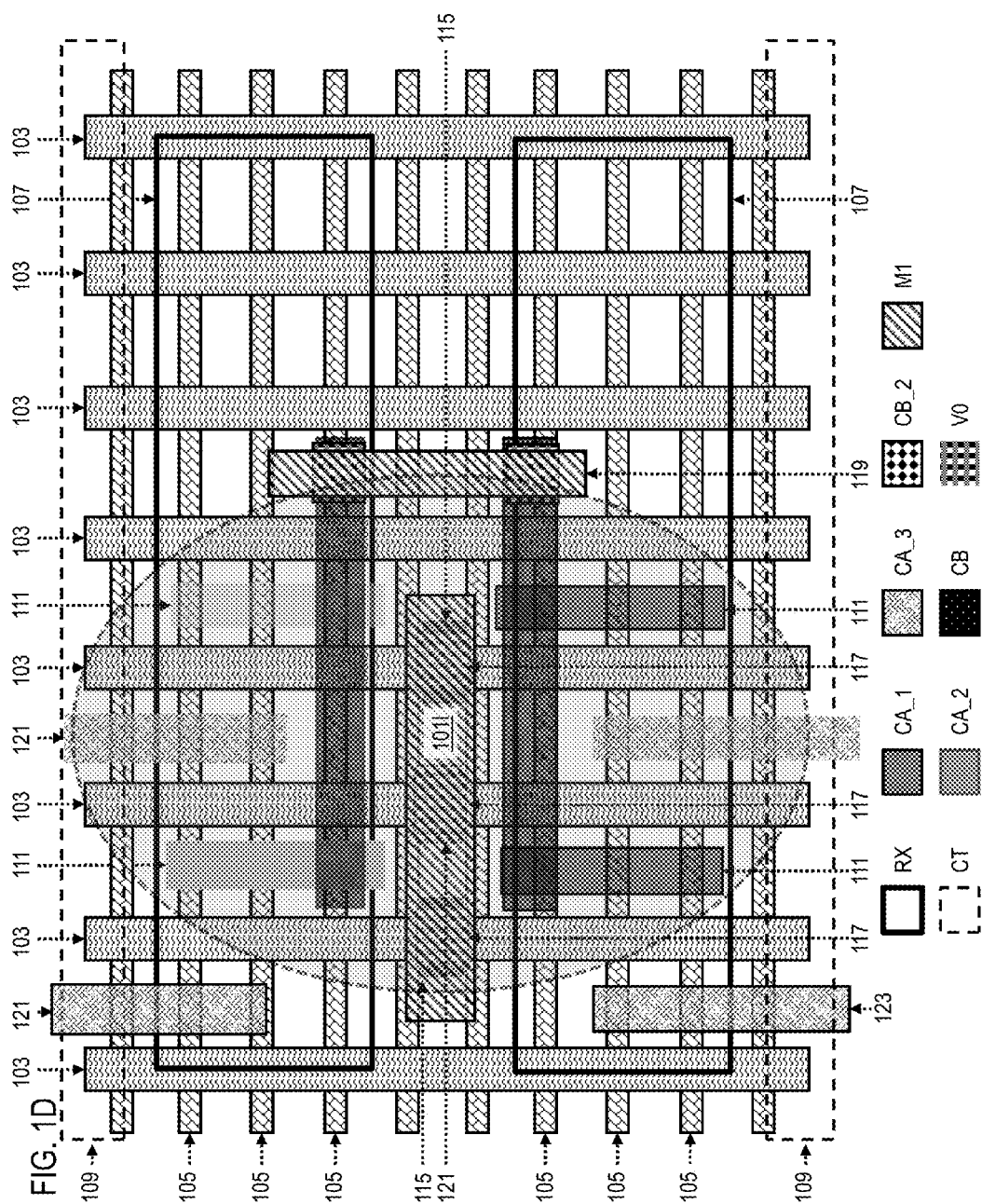
20 Claims, 5 Drawing Sheets











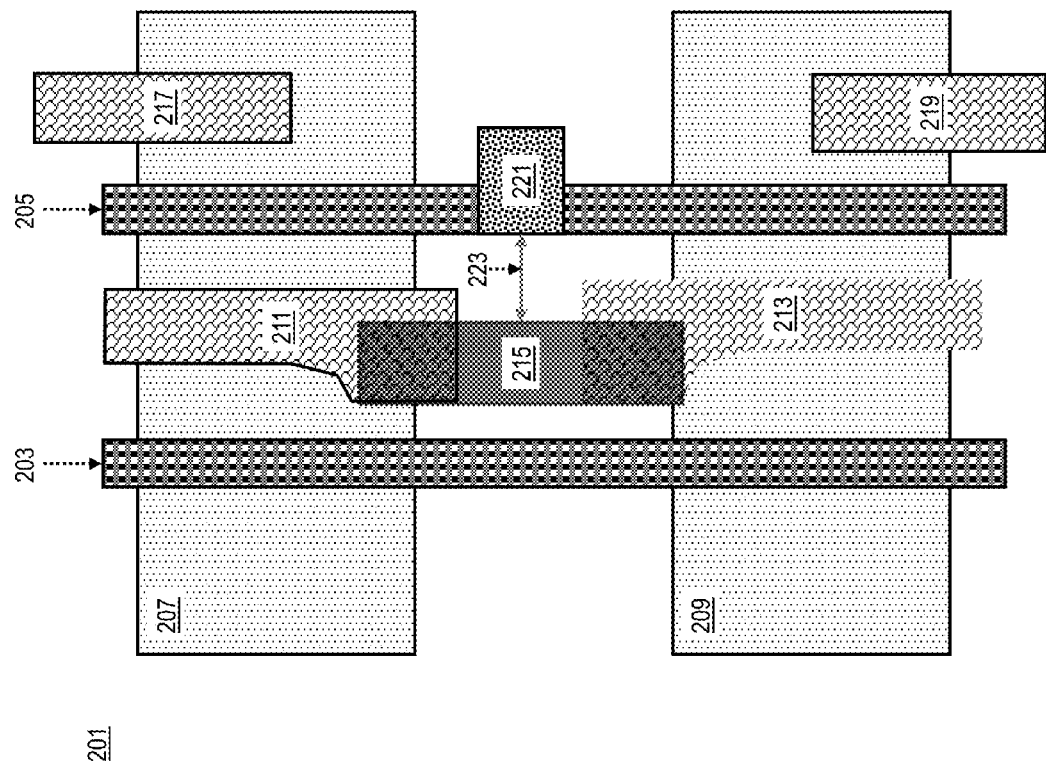


FIG. 2

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MIDDLE-OF-THE-LINE CONSTRUCTS USING DIFFUSION CONTACT STRUCTURES

CROSS REFERENCED TO RELATED APPLICATION

This application is a divisional of U.S. application Ser. No. 13/568,737, filed Aug. 7, 2012, the content of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

The present disclosure relates to middle-of-the-line (MOL) constructs. The present disclosure is particularly applicable to MOL constructs for 14 nanometer (nm) technology nodes and beyond.

BACKGROUND

As technology advances, the importance of logic scaling continues to grow. However, traditional approaches to logic scaling are no longer effective due to lithographic limitations. In recent years, double and triple patterning techniques have been implemented for metal layer structures to mitigate the effects of such limitations by enabling metal layer structures to be formed closer to each other. However, the use of additional patterning processes also have their limits with respect to logic scaling as a result of increased complexities, high costs, and reliability issues that may be associated with further patterning (e.g., quadruple patterning) of these metal layer structures.

A need therefore exists for other logic-scaling-related constructs that do not rely on further patterning of metal layer structures, and enabling methodology.

SUMMARY

An aspect of the present disclosure is a method for implementing middle-of-the-line constructs using diffusion contact structures.

Another aspect of the present disclosure is a device implemented with middle-of-the-line constructs using diffusion contact structures.

Additional aspects and other features of the present disclosure will be set forth in the description which follows and in part will be apparent to those having ordinary skill in the art upon examination of the following or may be learned from the practice of the present disclosure. The advantages of the present disclosure may be realized and obtained as particularly pointed out in the appended claims.

According to the present disclosure, some technical effects may be achieved in part by a method including: providing a first diffusion region in a substrate; providing, via a first lithography process, a first diffusion contact structure; providing, via a second lithography process, a second diffusion contact structure; and coupling the first diffusion contact structure to the first diffusion region and the second diffusion contact structure.

Aspects of the present disclosure include the first and second lithography processes being performed at different times. Additional aspects include: providing a second diffusion region in the substrate; providing, via the first lithography process, a third diffusion contact structure; and coupling the third diffusion contact structure to the second diffusion region and the second diffusion contact structure. Various aspects include providing the first diffusion contact structure to have

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a first width, and the second diffusion contact structure to have a second width that is different from the first width.

Certain aspects include: providing a first gate structure over the substrate; and providing the second diffusion contact structure over the first gate structure. Some aspects include: providing a second gate structure over the substrate; providing a gate contact over the second gate structure; and providing the second diffusion contact structure to be a pre-designated distance away from the gate contact. Other aspects include: providing a gate contact over the first gate structure; and coupling the second diffusion contact structure to the gate contact. Further aspects include: providing a second gate structure over the substrate; and providing the second diffusion contact structure across the second gate structure to couple the first diffusion contact structure to the gate contact.

An additional aspect of the present disclosure is a device including: a first diffusion region in a substrate; and first and second diffusion contact structures, wherein the first diffusion contact structure is provided via a first lithography process, the second diffusion contact structure is provided via a second lithography process, and the first diffusion contact structure is coupled to the first diffusion region and the second diffusion contact structure.

Aspects include the first and second lithography processes being performed at different times. Additional aspects include a device having: a second diffusion region in the substrate; and a third diffusion contact structure, wherein the third diffusion contact structure is provided via the first lithography process, and the third diffusion contact structure is coupled to the second diffusion region and the second diffusion contact structure. Some aspects include the first diffusion contact structure having a first width, and the second diffusion contact structure having a second width that is different from the first width.

Certain aspects include a device having a first gate structure over the substrate, wherein the second diffusion contact structure is over the first gate structure. Various aspects include a device having: a second gate structure over the substrate; and a gate contact over the second gate structure, wherein the second diffusion contact structure is a pre-designated distance away from the gate contact. Some aspects include a device having a gate contact over the first gate structure, wherein the second diffusion contact structure is coupled to the gate contact. Further aspects include a device having a second gate structure over the substrate, wherein the second diffusion contact structure crosses over the second gate structure and couples the first diffusion contact structure to the gate contact.

Another aspect of the present disclosure includes: providing a first diffusion region in a substrate; providing a plurality of fin structures over the first diffusion region; providing a diffusion contact structure over at least one of the fin structures; and coupling the diffusion contact structure to the first diffusion region.

Additional aspects include: providing a gate structure over the substrate; providing a gate contact over the gate structure; and coupling the diffusion contact structure to the gate contact. Some aspects include the diffusion contact structure being oriented perpendicularly to the gate contact. Further aspects include: providing a second diffusion region in the substrate; providing a diffusion gap region between the first and second diffusion regions; providing the diffusion contact structure over the diffusion gap region; and coupling, via the diffusion contact structure, the first and second diffusion regions.

Additional aspects and technical effects of the present disclosure will become readily apparent to those skilled in the art

from the following detailed description wherein embodiments of the present disclosure are described simply by way of illustration of the best mode contemplated to carry out the present disclosure. As will be realized, the present disclosure is capable of other and different embodiments, and its several details are capable of modifications in various obvious respects, all without departing from the present disclosure. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not as restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawing and in which like reference numerals refer to similar elements and in which:

FIGS. 1A through 1D schematically illustrate various MOL constructs using diffusion contact structures, in accordance with various exemplary embodiments of the present disclosure; and

FIG. 2 schematically illustrates additional details with respect to a MOL construct using diffusion contact structures, in accordance with an exemplary embodiment of the present disclosure.

DETAILED DESCRIPTION

In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of exemplary embodiments. It should be apparent, however, that exemplary embodiments may be practiced without these specific details or with an equivalent arrangement. In other instances, well-known structures and devices are shown in block diagram form in order to avoid unnecessarily obscuring exemplary embodiments. In addition, unless otherwise indicated, all numbers expressing quantities, ratios, and numerical properties of ingredients, reaction conditions, and so forth used in the specification and claims are to be understood as being modified in all instances by the term "about."

The present disclosure addresses and solves problems of logic scaling limitations attendant upon typical metal layer patterning techniques. The present disclosure addresses and solves such problems, for instance, by, inter alia, providing a first diffusion contact structure via a first lithography process, and a second diffusion contact structure via a second lithography process, and coupling the first contact structure to a first diffusion region and the second diffusion contact structure.

FIGS. 1A through 1D schematically illustrate various MOL constructs, or local interconnects, using diffusion contact structures, in accordance with exemplary embodiments of the present disclosure. For example, FIG. 1A depicts various MOL constructs **101a**, **101b**, **101c**, **101d**, **101e**, and **101f** that may be implemented using or along with gate structures **103**, fin structures **105**, diffusion regions (RX) **107**, gate cut regions (CT) **109**, diffusion contact structures (CA) **111** and **113**, gate contacts (CB) **115**, via0 structures (V0) **117**, and metal layer structures (M1) **119**. As indicated in FIG. 1A, diffusion contact structures **111** are formed through a first patterning process, and diffusion contact structures **113** are formed through a second patterning process.

As shown, construct **101a** includes diffusion contact structures **111** and **113** that are stitched together (e.g., using Litho-Etch-Litho-Etch (LELE) techniques) to couple diffusion regions **107** (e.g., to connect drains of NFETs to drains of PFETs), where the diffusion contact structures **111** have widths that are greater than a width of the diffusion contact

structure **113** (e.g., with respect to the horizontal orientation of FIG. 1A). On the other hand, construct **101b** includes diffusion contact structures **111** and **113** that are stitched together to couple diffusion regions **107** (e.g., to connect drains of NFETs to drains of PFETs), where the diffusion contact structures **111** have widths that are less than a width of the diffusion contact structure **113**. As illustrated, the various ways in which diffusion contact structures **111** and **113** are stitched together enable construct **101a** to pass by a gate contact **115** to its left and construct **101b** to pass by the gate contact **115** to its right without violating a design rule that requires diffusion contact structures **111** and **113** to be at least a predefined distance away from gate contacts **115**, for instance, even though certain portions of constructs **101a** and **101b** are less than the predefined distance away from the gate structure **103** on which the particular gate contact **115** sits.

Construct **101c** provides for the coupling of source/drain regions (e.g., of the top diffusion region **107**) to a gate structure **103** via the connecting of a diffusion contact structure **111** to a diffusion contact structure **113** and the connecting of the diffusion contact structure **113** to a gate contact **115** that sits over the gate structure **103**. Construct **101d** provides for the coupling of source/drain regions (e.g., of the bottom diffusion region **107**) to a gate structure **103** via the connecting of a diffusion contact structure **111** to one end of a diffusion contact structure **113** that crosses over (and is electrically isolated from) another gate structure **103** and the connecting of the other end of the diffusion contact structure **113** to a gate contact **115** that sits over the gate structure **103**.

Construct **101e** includes a diffusion contact structure **111** that is over a plurality of fin structures **105** and connected to a gate contact **115** through a CA/CB handshake that enables the coupling of top diffusion region **107** to a gate structure **103** (on which the gate contact **115** sits) without requiring the diffusion contact structure **111** to be over the gate structure **103**. Construct **101f** includes a diffusion contact structure **111** that is provided over a gate structure **103**, a plurality of fin structures **105**, and the diffusion gap region between top and bottom diffusion regions **107** to couple source/drain regions of those diffusion regions **107** (e.g., to connect drains of NFETs to drains of PFETs). In this way, constructs **101a**, **101b**, **101c**, **101d**, **101e**, and **101f** allow for further logic scaling (e.g., up to 15% logic scaling benefit), for instance, even without extreme ultraviolet (EUV) techniques, without changes to metal layer rules, or without additional patterning for metal layer structures. In addition, because the timely availability of EUV for 14 nm and 10 nm technologies is uncertain (e.g., due to the need for some technology breakthroughs that have not yet occurred), innovation of such constructs to scale logic technology at reasonable costs becomes increasingly important for the future.

Moreover, FIG. 1B illustrates constructs **101g**, **101h**, and **101i**. Like construct **101a**, constructs **101g** includes diffusion contact structures **111** and **113** that are stitched together to couple diffusion regions **107** (e.g., to connect drains of NFETs to drains of PFETs), where the diffusion contact structures **111** have widths that are greater than a width of the diffusion contact structure **113**. In addition, like construct **101b**, each of constructs **101h** and **101i** includes diffusion contact structures **111** and **113** that are stitched together to couple diffusion regions **107** (e.g., to connect drains of NFETs to drains of PFETs), where the diffusion contact structures **111** have widths that are less than a width of the diffusion contact structure **113**. As discussed, the various ways in which diffusion contact structures **111** and **113** are stitched together enable the different constructs **101g**, **101h**, and **101i** to pass by particular gate contacts **115** without

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violating a design rule that requires diffusion contact structures **111** and **113** to be at least a predefined distance away from gate contacts **115** (e.g., regardless of whether certain portions of the constructs **101g**, **101h**, and **101i** are less than the predefined distance away from a gate structure **103** on which a gate contact **115** sits).

FIG. 1C illustrates constructs **101j** and **101k**. For example, construct **101j** includes a first diffusion contact structure **111** over source/drain regions of the top diffusion region **107**, a second diffusion contact structure **111** over source/drain regions of the bottom diffusion region **107**, and a third diffusion contact structure **113** that cross over gate structure **103** to connect first and second diffusion contact structures **111**. As such, construct **101j** may be utilized to couple source/drain regions of the top diffusion region **107** to source/drain regions of the bottom diffusion region **107** that are not between the same two gate structures **103** (e.g., to connect different NFETs and PFETs together), without relying on metal layer structures to perform such coupling. In addition, as shown, construct **101j** takes advantage of the double diff break region (or the diffusion gap region having two fin structures associated with a set of dummy gates) in between top and bottom diffusion regions **107** (e.g., each having a plurality of source/drain regions) by performing the connection of the first and second diffusion contact structures **111** using the third diffusion contact structure **113** that is over the double diff break region (e.g., to utilize the double diff break regions).

Likewise, construct **101k** also takes advantage of the double diff break region between top and bottom diffusion regions **107**. Specifically, construct **101k** includes a first diffusion contact structure **111** over top and bottom diffusion regions **107**, along with a second diffusion contact structure **113** that couples to the first diffusion contact structure **111** at one end and to via0 structure **117** within the double diff break region at another end, for instance, to enable metal layer routing that utilizes the double diff break region (e.g., to enable more room within diffusion regions **107** for other purposes).

FIG. 1D illustrates construct **101l**, for instance, that enables parallel transistor connections using diffusion contact structures **111** and **113** (e.g., to form multi-finger inverters). As shown, construct **101l** includes first and second diffusion contact structures **111** over top diffusion region **107**, where each of these diffusion contact structures **111** is between two different sets of gate structures **103**. Moreover, construct **101l** includes third and fourth diffusion contact structures **111** over bottom diffusion region **107**, where each of these diffusion contact structures **111** is also between two different sets of gate structures **103**. In addition, construct **101l** includes fifth and sixth diffusion contact structures **113** that cross over multiple gate structures **103** to respectively connect ends of the first and second diffusion contact structures **111** and ends of the third and fourth diffusion contact structures **111** to two different portions of a metal layer structure **119** (e.g., through gate contacts **115** and via0 structures **117**). Furthermore, construct **101l** may include gate contacts **115** formed through one patterning process and gate contacts **121** formed through another patterning process, along with diffusion contact structures **123** formed through a patterning process that is performed separately from the patterning processes utilized for diffusion contact structures **111** and **113** (e.g., three separate lithography processes may be utilized to form diffusion contact structures **111**, **113**, and **123**).

FIG. 2 schematically illustrates additional details with respect to a MOL construct using diffusion contact structures, in accordance with an exemplary embodiment of the present

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disclosure. For example, FIG. 2 depicts construct **201** with gate structures **203** and **205** over diffusion regions **207** and **209**, along with diffusion contact structures **211**, **213**, **215**, **217**, and **219**, and gate contact **221** over gate structure **205**. Diffusion contact structures **211** and **213** may, for instance, be formed through a first patterning process, and diffusion contact structure **215** may be formed through a second patterning process separate from the first patterning process. Diffusion contact structures **217** and **219** may be formed through either the first or second patterning process based on the contact poly pitch (CPP) that construct **201** is associated with.

Construct **201** may be provided by stitching together diffusion contact structures formed by separate patterning processes (e.g., using LELE techniques). For example, one end of diffusion contact structure **215** may be coupled to diffusion contact structure **211**, and the other end of diffusion contact structure **215** may be coupled to diffusion contact structure **213**. As shown, this stitch-based approach enables diffusion contact construct **201** to pass by gate contact **221** while maintaining at least a predefined distance **223** between construct **201** and gate contact **221**, even though certain portions of construct **201** may be less than the predefined distance **223** away from the gate structure **205** on which gate contact **221** sits. In addition, construct **201** may be utilized for a variety of CPP designs (e.g., 90 nm CPP or below), and may reduce the amount of chip area required (e.g., by ~5% even without changes to metal rules and capabilities). Other advantages of construct **201** may, for instance, include making 78 nm CPP a viable technology with 64 nm LELE metal with respect to 90 nm CPP, and allowing easy migration to EUV designs with a single mask.

The embodiments of the present disclosure can achieve several technical effects, including reduced device size without significant increases in costs, complexities, etc. Embodiments of the present disclosure enjoy utility in various industrial applications as, for example, microprocessors, smart phones, mobile phones, cellular handsets, set-top boxes, DVD recorders and players, automotive navigation, printers and peripherals, networking and telecom equipment, gaming systems, and digital cameras. The present disclosure therefore enjoys industrial applicability in any of various types of highly integrated semiconductor devices, particularly in 14 nm and 10 nm technologies nodes and beyond.

In the preceding description, the present disclosure is described with reference to specifically exemplary embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the present disclosure, as set forth in the claims. The specification and drawings are, accordingly, to be regarded as illustrative and not as restrictive. It is understood that the present disclosure is capable of using various other combinations and embodiments and is capable of any changes or modifications within the scope of the inventive concept as expressed herein.

What is claimed is:

1. A device comprising:

a first diffusion region in a substrate; and

first and second diffusion contact structures, wherein the first diffusion contact structure is provided via a first lithography process, the second diffusion contact structure is provided via a second lithography process, and the first diffusion contact structure is coupled to the first diffusion region and the second diffusion contact structure,

wherein the first and second diffusion contact structures are couple together by stitching the first and second diffusion contact structures, such that the first and sec-

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ond diffusion contact structures include an overlapping area of the first and second diffusion contact structures, and the overlapping area of the first and second diffusion contact structures, in a plan view, covers less than all of the first and less than all of the second diffusion contact structures.

2. The device according to claim 1, wherein the first and second lithography processes are performed at different times.

3. The device according to claim 1, further comprising:

a second diffusion region in the substrate; and

a third diffusion contact structure, wherein the third diffusion contact structure is provided via the first lithography process, and the third diffusion contact structure is coupled to the second diffusion region and the second diffusion contact structure.

4. The device according to claim 1, wherein the first diffusion contact structure has a first width, and the second diffusion contact structure has a second width that is different from the first width.

5. The device according to claim 1, further comprising:

a first gate structure over the substrate, wherein the second diffusion contact structure is over the first gate structure.

6. The device according to claim 5, further comprising:

a second gate structure over the substrate; and

a gate contact over the second gate structure, wherein the second diffusion contact structure is a pre-designated distance away from the gate contact.

7. The device according to claim 5, further comprising:

a gate contact over the first gate structure, wherein the second diffusion contact structure is coupled to the gate contact.

8. The device according to claim 7, further comprising:

a second gate structure over the substrate, wherein the second diffusion contact structure crosses over the second gate structure and couples the first diffusion contact structure to the gate contact.

9. The device according to claim 1, wherein the first diffusion contact structure is coupled to the first diffusion region and the second diffusion contact structure by connecting drains of NFETs to drains of PFETs.

10. The device according to claim 3, wherein the second diffusion contact structure overlaps both the first diffusion contact structure and the third diffusion contact structure, and the overlapping area of the second diffusion contact structure and the third diffusion contact structure covers less than all of the second and third diffusion contact structures.

11. A device comprising:

a first diffusion region in a substrate;

at least one metal1 (M1) layer of the substrate;

a first diffusion contact structure, formed through a first lithography process, the first diffusion contact structure being separated from the at least one metal1 (M1) layer of the substrate;

a second diffusion contact structure, formed through a second lithography process, wherein the first and second lithography processes are performed at different times; the first diffusion contact structure coupled to the first diffusion region and the second diffusion contact structure, and

first and second diffusion contact structures for coupling of the first diffusion contact structure to the second diffusion contact structure by stitching the first and second diffusion contact structures, such that the first and second diffusion contact structures include an overlapping area of the first and second diffusion contact structures,

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and the overlapping area, in a plan view, covers less than all of the first and less than all of the second diffusion contact structures.

12. The device according to claim 11, further comprising: a second diffusion region in the substrate; and

a third diffusion contact structure;

wherein the third diffusion contact structure is coupled to the second diffusion region and the second diffusion contact structure.

13. The device according to claim 11, wherein the first diffusion contact structure has a first width, and the second diffusion contact structure has a second width different from the first width.

14. The device according to claim 11, further comprising: a first gate structure over the substrate;

wherein the second diffusion contact structure is provided over the first gate structure.

15. The device according to claim 10, further comprising:

a second gate structure over the substrate; and

a gate contact over the second gate structure;

wherein the second diffusion contact structure is a pre-designated distance away from the gate contact.

16. The device according to claim 15, further comprising:

a gate contact over the first gate structure;

wherein the second diffusion contact structure is coupled to the gate contact.

17. The device according to claim 16, further comprising:

a second gate structure over the substrate;

wherein the second diffusion contact structure is located across the second gate structure and couples the first diffusion contact structure to the gate contact.

18. A device comprising:

a first diffusion region in a substrate;

at least one metal1 (M1) layer of the substrate;

a plurality of fin structures over the first diffusion region;

first, second, and third diffusion contact structures, the first diffusion contact structure coupled to the first diffusion region, and the third diffusion contact structure coupled to a second diffusion region in the substrate;

the second diffusion contact structure located over at least one of the fin structures, and overlapping the first and third diffusion contact structures, the second diffusion contact structure being separated from the at least one metal1 (M1) layer of the substrate;

the second diffusion contact structure coupled to the first diffusion region via the first diffusion contact structure; a diffusion gap region between the first and second diffusion regions;

the second diffusion contact structure located over the diffusion gap region; and

the first and second diffusion regions coupled, via the second diffusion contact structure, by stitching the second diffusion contact structure to the first and third diffusion contact structures,

wherein a portion of the second diffusion contact structure maintains a predefined distance from a gate contact,

wherein the first and second diffusion contact structures include an overlapping area of the first and second diffusion contact structures, and the overlapping area of the first and second diffusion contact structures, in a plan view, covers less than all of the first and less than all of the second diffusion contact structures, and

wherein the second and third diffusion contact structures include an overlapping area of the second and third diffusion contact structures, and the overlapping area of the second and third diffusion contact structures, in a

plan view, covers less than all of the second and less than all of the third diffusion contact structures.

19. The device according to claim **18**, further comprising:
a gate structure over the substrate;

wherein the gate contact is located over the gate structure; 5

and

the diffusion contact structure is coupled to the gate contact.

20. The device according to claim **19**, wherein the diffusion contact structure is oriented perpendicularly to the gate contact. 10

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 9,142,513 B2
APPLICATION NO. : 14/645598
DATED : September 22, 2015
INVENTOR(S) : Mahbub Rashed et al.

Page 1 of 1

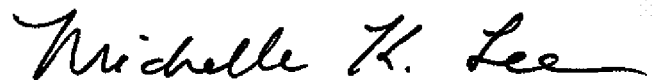
It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the title page, line 7, item 72, the 7th inventor's information which reads:

“Jongwook K E, Pleasanton, CA (US)” should read:

“Jongwook KYE, Pleasanton, CA (US)”

Signed and Sealed this
Fifteenth Day of March, 2016

A handwritten signature in black ink, reading "Michelle K. Lee". The signature is written in a cursive style with a long, sweeping underline.

Michelle K. Lee
Director of the United States Patent and Trademark Office